FactSheet

National Aeronautics and Space Administration
February 2004

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NASA'S HUMAN FACTORS RESEARCH PROGRAM IN COLLABORATION WITH THE UNIVERSITY OF COLORADO

Studies in ATC Message Comprehension

Air Traffic Control sends messages to an aircrew, with the pilots reading back and then following the instructions.

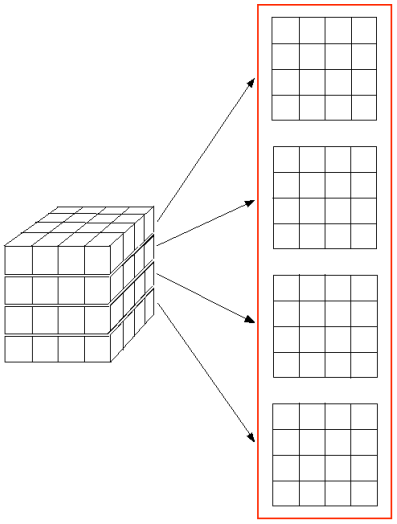
Controller: "Expo nine two you're niner miles from Laker, turn left heading three one zero, maintain three thousand till established on the localizer, cleared ILS runway two eight right approach, maintain one seven zero knots until Laker."

Pilot: "That's two one, uh zero on the heading and, uh- one seventy till Laker."

In the example given, the pilot reads back the wrong compass heading (he says "two one zero" instead of "three one zero"), though he is correct on speed. He also neglects to acknowledge the altitude restriction and the approach clearance and omits the aircraft identification. This omission prevents the controller from ascertaining that the intended crew received the correct clearance. Such a partial and erroneous readback could be hazardous.

A laboratory task has been designed to simulate communication between air traffic control and flightcrews. In this task, participants hear directions like those given by air traffic controllers; they repeat the directions aloud, as pilots are expected to do; and then they follow the directions, navigating in the space displayed on the computer. The oral repetition of the directions provides a measure of immediate memory for the directions, whereas the implementation of the directions provides a strict test of both message memory and comprehension.

The directions describe movements in a grid of four 4 X 4 matrices stacked one on top of another and representing a three-dimensional space on a computer screen. A sample set of directions including three commands is: "Turn left two squares; climb down one level; move forward one step." Upon hearing such directions, the participant immediately repeats them aloud, and, next, to demonstrate comprehension, uses the computer mouse to follow the directions, by clicking each appropriate square on the grid in the order specified.



On the left is the three-dimensional space that is depicted on the computer screen by the grid of matrices shown on the right.

Experiments are conducted in which the number of directions is varied in the messages to determine the optimal number that can be understood, remembered, and followed. Also, the readback requirement is removed in some experimental conditions or readback is abbreviated by requiring participants to recall only the key words of the messages (for example, "left two, down one, forward one" in the sample).

Findings

- Messages with three or fewer elements can be read back and followed with few problems, but errors increase substantially when four or more elements are given.
- Increasing the number of words in a given element, however, generally does not lead to an increase in errors. There is no performance penalty for redundancy.

Conclusions

- To maximize comprehension and to minimze the opportunity for error, air traffic controllers should limit a given message to no more than three elements at a time.
- A given instruction does not need to be shortened; there is no need to save on words, given their power to disambiguate messages (as in the case of speed, heading, and altitude that can all use two-five-zero as their numbers).

For more information, visit:
http://human-factors.arc.nasa.gov/ *or*
http://psych.colorado.edu/~ahealy/welcome.html

A subject in a message comprehension experiment at the University of Colorado.